



5. EXPOSURE POINT CONCENTRATIONS

To quantify exposures, statistically representative concentrations were estimated for constituents of potential concern (COPCs) in impacted environmental media. These COPC *exposure point concentrations* were assumed equal to the representative concentration in the medium (direct exposures) or were predicted by transport modeling (indirect exposures). Fate and transport models provide the only means of predicting COPC concentrations at potential exposure locations because, by definition, data on future concentrations are unavailable. This section describes the methodologies used in the statistical derivation of exposure point concentrations for direct and indirect exposures.

Section 5.1 presents the methodology used to identify areas of potential concern (AOPCs). AOPCs represent potential “hot-spots” and have been designed to ensure that exposure point concentrations are not underestimated as a function of statistical dilution.

Section 5.2 discusses the statistical methods used in the evaluation of Parcel A soils data and presents the resultant exposure point concentrations for soils. These soil exposure point concentrations are then used in a detailed air transport analysis in Section 5.3 to project potential exposure point concentrations in air.

5.1 IDENTIFICATION OF AREAS OF POTENTIAL CONCERN

There is currently no DTSC/HERD guidance concerning the identification of AOPCs in the risk assessment process. The methodology to be used is chosen on a site-specific basis by DTSC/HERD and site representatives. The following AOPC identification methodology has been agreed to by DTSC/HERD and Integrated for Parcel A (IESI 1998a):



1. Plot all COPCs with maximum detected concentrations exceeding EPA Region IX residential PRGs or DTSC/HERD surrogate values to identify potential hot spots or clusters of constituents.
2. Develop AOPCs to encompass plotted points of similar constituents and/or continuous lateral distribution in soils, and to account for direct (soils) and indirect (emission) points of exposure.

No AOPCs were identified for indirect (emission) exposures; all detected VOCs are below residential PRGs. Therefore, because no localized hot spots were identified, indirect exposures were assessed on a parcel-wide basis.

For direct (soil) exposures, one AOPC was identified in the northeast quadrant of the parcel (Figure 5-1). Note that the area outside AOPC 1 is still assessed in the risk assessment, but analytical samples do not indicate the need to assess potentially localized exposures. AOPC 2 was created to address the area outside AOPC 1. Thus, all of Parcel A has been addressed in this risk assessment. At the request of DTSC, additional AOPC divisions were evaluated to test for potential statistical dilution. No significant statistical differences were noted (IESI 1998d).

The use of AOPCs in this risk assessment ensures that estimated exposures are conservative and not underestimated as a result of statistical dilution.

5.2 STATISTICAL EVALUATION OF DATA

Statistical methods were used to evaluate the numerous soil analytical results from the Parcel A sampling to: 1) characterize the statistical distribution of COPCs, 2) develop source-term concentrations for fate and transport modeling (soils data for 0 to 50 feet bgs), and 3) establish soil exposure-point concentrations (soils data for 0 to 12 feet bgs). The rationale used to develop this methodology and the statistical techniques are based on the following sources:



- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual, Part A (EPA 1989a)
- Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 1 (EPA 1989b)
- Statistical Methods for Environmental Pollution Monitoring (Gilbert 1987)
- Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities (EPA 1989c)

For each soil COPC, statistical summaries were developed, including the arithmetic mean, standard error of the arithmetic mean, minimum measured concentration, maximum measured concentration, frequency of detection, D'Agostino's test for distribution, fit testing, and 95 percent upper confidence limit (UCL) of the mean (see Appendices C and D). The applicability of D'Agostino's test and the 95 percent UCL of the mean is discussed below. First, however, an approach for the assignment of values for non-detected results is addressed.

5.2.1 Treatment of Non-Detected Constituents

Every analytical technique used to measure the concentration of constituents has an associated limit of detection (LOD) and limit of quantification (LOQ). A constituent that was not detected in a sample is below the LOD. A constituent that was detected but in such low amounts that its concentration could not be accurately determined is below the LOQ. When a constituent is reported as not detected in a sample, the actual concentration is any value up to the LOD.

For this post-demolition risk assessment, when a constituent was found in some of the samples and was not clearly spatially limited, it is assumed to exist in samples in which it was not detected. The assignment of a value of one-half the detection limit (if the constituent is normally distributed), or the detection limit divided by the square root of 2 (if the constituent is lognormally distributed), or the LOD to all samples reported as not detected reflects the assumption that the samples are equally likely to have any value up to the detection limit. Furthermore, when the sample values above the LOQ are lognormally distributed, it is



reasonable to assume that values below the LOQ are also lognormally distributed, and the reported detection limit divided by the square root of 2 should be assigned as a proxy value (Cal/EPA 1992, EPA 1988a, 1988b).

5.2.2 Determination of Data Distribution

The data set distribution must be determined prior to the application of any statistical methods. This minimizes the effect of data biasing. D'Agostino's test (Gilbert 1987) is an effective method for testing whether a data set has been drawn from an underlying normal distribution (see Appendix D). Conducting the test on the logarithms of the data is an equally effective way of evaluating the hypothesis of a lognormal distribution. The data sets for the post-demolition risk assessment were found to best fit the lognormal distribution and were statistically evaluated in this manner.

5.2.3 Use of 95 Percent Upper Confidence Limit Concentrations

Due to the uncertainty associated with characterizing potentially heterogeneous media, the 95 percent UCL for either a normal or lognormal distribution must be used to represent constituent concentrations (Cal/EPA 1992, EPA 1988a, 1988b). As previously mentioned, the Parcel A data were determined to be lognormally distributed. Thus, the upper 95 percent UCL for lognormal distribution was used for soil source-term concentrations (see Appendix D).

Tables 5-1 and 5-2 summarize the 95 percent UCL concentrations for the soil COPCs by AOPC as calculated for direct exposures (0 to 12 feet bgs) and long-term fate and transport modeling (0 to 50 feet bgs). It is important to note that when the 95 percent UCL exceeded the maximum detected value, the maximum detected value was used. This approach is consistent with DTSC guidance (Cal/EPA 1994).

The values presented in Tables 5-1 and 5-2 are used throughout the post-demolition risk assessment.



TABLE 5-1
95 PERCENT UCL CONCENTRATIONS
OF SOIL COPCs, 0 TO 12 FT bgs

COPC	Concentration (mg/kg)	
	AOPC 1	AOPC 2
1,1-dichloroethene	<u>2.57E-03</u>	<u>4.05E-03</u>
1,2,4-trimethylbenzene	<u>3.82E-03</u>	<u>1.85E-02</u>
1,3,5-trimethylbenzene	<u>2.96E-03</u>	<u>8.93E-03</u>
aroclor 1248	<u>3.69E-02</u>	<u>1.63E-02</u>
<u>aroclor 1254</u>	<u>3.28E-02</u>	<u>1.63E-02</u>
aroclor 1260	<u>2.08E-02</u>	<u>1.72E-02</u>
<u>arsenic</u>	<u>1.56E+00</u>	<u>ND</u>
benzo(a)anthracene	<u>2.43E-01</u>	<u>1.06E-01</u>
benzo(a)pyrene	<u>3.39E-01</u>	<u>2.24E-01</u>
benzo(b)fluoranthene	<u>3.91E-01</u>	<u>2.28E-01</u>
<u>benzo(k)fluoranthene</u>	<u>3.06E-01</u>	<u>2.05E-01</u>
bis(2-ethylhexyl)phthalate	<u>2.58E-01</u>	<u>1.03E-01</u>
chrysene	<u>2.86E-01</u>	<u>1.22E-01</u>
dibenzo(a,h)anthracene	<u>1.36E-01</u>	<u>8.54E-02</u>
fluoranthene	<u>2.66E-01</u>	<u>1.18E-01</u>
<u>indeno(1,2,3-cd)pyrene</u>	<u>3.33E-01</u>	<u>2.12E-01</u>
naphthalene	<u>2.05E-01</u>	<u>2.15E-01</u>
n-butylbenzene	<u>2.81E-03</u>	<u>6.18E-03</u>
n-propylbenzene	<u>2.57E-03</u>	<u>5.78E-03</u>
p-cymene	<u>2.47E-03</u>	<u>6.45E-03</u>
phenanthrene	<u>2.03E-01</u>	<u>1.42E-01</u>
pyrene	<u>3.12E-01</u>	<u>1.28E-01</u>
tetrachloroethylene	<u>2.69E-03</u>	<u>4.52E-03</u>
trichloroethylene	<u>2.63E-03</u>	<u>8.56E-03</u>
xylene	<u>2.34E-03</u>	<u>6.45E-03</u>

ND = Not Detected above background in AOPC.



TABLE 5-2
95 PERCENT UCL CONCENTRATIONS
OF SOIL COPCs, 0 TO 50 FT bgs

COPC	Concentration (mg/kg)	
	AOPC 1	AOPC 2
1,1-dichloroethene	2.74E-03	6.83E-03
1,2,4-trimethylbenzene	4.63E-03	2.30E-02
1,3,5-trimethylbenzene	3.44E-03	1.02E-02
aroclor 1248	3.86E-02	1.66E-02
aroclor 1254	3.18E-02	1.66E-02
aroclor 1260	2.07E-02	1.74E-02
arsenic	1.53E+00	ND
benzo(a)anthracene	2.26E-01	1.05E-01
benzo(a)pyrene	3.22E-01	2.18E-01
benzo(b)fluoranthene	3.68E-01	2.11E-01
benzo(k)fluoranthene	2.93E-01	1.99E-01
bis(2-ethylhexyl)phthalate	2.35E-01	9.47E-02
chrysene	2.66E-01	1.19E-01
dibenzo(a,h)anthracene	1.46E-01	8.17E-02
fluoranthene	2.42E-01	1.15E-01
indeno(1,2,3-cd)pyrene	3.18E-01	2.03E-01
naphthalene	2.15E-01	2.42E-01
n-butylbenzene	2.95E-03	6.00E-03
n-propylbenzene	2.87E-03	6.60E-03
p-cymene	2.78E-03	6.08E-03
phenanthrene	2.00E-01	1.33E-01
pyrene	2.85E-01	1.30E-01
tetrachloroethylene	2.86E-03	4.14E-03
trichloroethylene	2.79E-03	1.07E-02
xylene	2.59E-03	5.45E-03

ND = Not Detected above background in AOPC.



5.3 AIR TRANSPORT ANALYSIS

An analysis of the transport of COPCs from the site through the air pathway was conducted to assess potential receptor exposure concentrations. This section describes the methodology and results of the air transport analysis.

The objective of this analysis was to determine the maximum on- and off-site annual average air concentrations of the COPCs released to the atmosphere from soil sources. These concentrations were used in the risk assessment as shown in the conceptual exposure model (CEM) in Section 4 (Figure 4-1).

This air transport analysis estimates the airborne COPC concentrations for two emissions cases. The first case is applicable to the intrusive construction activities conducted during site development of the commercial/industrial facility and future maintenance. Soils are assumed to be uncovered (no cap and no vegetation), and all potential soil sources are assumed to contribute to airborne COPC concentrations. It is important to note that source-term concentrations for surface soils (0 to 12 feet bgs) were used in this case based on the receptor's potential for direct exposure to these soils.

The second emissions case estimates the airborne COPC concentrations for the completed commercial/industrial facility. This case assumes the property is entirely covered with pavement and/or landscaping, thus eliminating particulate emissions. However, to ensure conservative emission estimates, only the indoor air intrusion model has accounted for the attenuation effects of anticipated future site structures or volatile emissions. It is important to note that due to the long-term nature of this emissions case, all potential soil sources were evaluated regardless of depth.

The analysis followed guidelines developed by the EPA (1989a), Cal/EPA (1990, 1992), and South Coast Air Quality Management District (SCAQMD 1993). The sources of air emissions and the COPCs released were identified based on parcel-specific information (see Section 5.2).



Appropriate emission estimating techniques and available site data were used to calculate air emission rates. A regulatory-agency-approved air dispersion model was used to translate emission rates into annual average air concentrations.

Throughout the analysis, site-specific data were used where available. When such data were unavailable, conservative assumptions found in appropriate literature were used. Regulatory default options and values were used when applicable in the source emission calculations and air dispersion model. The intent of assumptions used in this analysis was to make the results relevant to Parcel A, yet conservative, so that the risk associated with this exposure pathway would not be underestimated.

5.3.1 Construction Emissions Case (Intrusive)

The inhalation exposures for the construction emissions case are characterized as indirect, meaning exposures occur away from or in a different medium from the source. The COPC concentrations at the point of exposure are typically lower than the representative value determined for the source medium. Therefore, to quantify exposure through indirect pathways, the reduction in COPC concentrations associated with each transport mechanism from the source medium to the point of exposure must be characterized in terms of an attenuation factor (Cal/EPA 1994).

Attenuation factors for the volatilization and particulate resuspension of COPCs were developed for use in the quantification of potential inhalation exposures associated with intrusive activities at Parcel A. These attenuation factors were used to correlate potential atmospheric exposure point concentrations originating from limited surface areas during construction and/or maintenance. Site-specific data were used where available with literature sources serving as a secondary source. The following sections present the methodology used in the development of these attenuation factors for each transport mechanism.



5.3.1.1 Volatilization Attenuation Factors

A volatilization emission model was used to calculate ambient air attenuation factors for COPCs that volatilize from soil. This is the same model used by EPA to develop preliminary remediation goals (EPA 1996b, 1996c). The volatilization model estimates the concentration of constituents emitted from soils and dispersed throughout ambient air during the transport from the source to the point of exposure. Estimating a volatilization attenuation factor for airborne concentrations of constituents in the volatilized phase involves modeling both emissions and dispersion. The emission component follows the mathematical model developed by Farmer et al. (Farmer 1980), while the dispersion component is the AREA-ST model, an updated version of the Industrial Source Complex Model 2 (ISC2) developed by the EPA Office of Air Quality Planning and Standards (EPA 1996a).

The emission component incorporates several assumptions (EPA 1986). This equation, based on Frick's First Law of steady-state diffusion, assumes that diffusion into the atmosphere occurs at a plane surface where concentrations remain constant. It ignores biodegradation, transport in water, adsorption, and production of landfill gas. Thus, diffusion of vapor through soil cover is the controlling factor. This emission component has been proposed as a method to calculate constituents concentrations in landfills without internal gas generation (EPA 1986).

The AREA-ST dispersion model is based on the Gaussian dispersion principle. Gaussian models assume that material that is continually released will be transported in a direction opposite to the wind direction, and time-averaged spreading of the pollutants will result in normal distribution if sampled in cross-sections of the plume. AREA-ST is extremely useful as a practical modeling tool, but it relies on several fundamental assumptions that must be noted. Emission rates are assumed to be constant and continuous. No variations occur in wind speed, wind direction, or Pasquill stability class during transport from source to receptor. The values used in the Parcel A modeling effort are either site specific or literature values designed to produce conservative results, thus ensuring that potential health impacts are not underestimated.



The volatilization attenuation factors for the Parcel A analysis were calculated as follows:

$$VF = Q/C \times [(3.1416 \times Z \times T)^{1/2} / (2 \times D_{ei} \times P_a \times K_{as})] \times UC1 \quad (5-1)$$

where

VF	=	volatilization attenuation factor (m ³ /kg)
Q/C	=	dispersion component, emission flux per unit concentration [(g/m ² /sec)/(kg/m ³)], from Equation 5-2
Z	=	intermediate conversion factor (cm ² /sec), from Equation 5-6
T	=	exposure interval (seconds), <u>3.15 x 10⁷ (commercial/industrial worker),</u> <u>1.26 x 10⁶ (construction worker)</u>
D _{ei}	=	effective diffusivity of a COPC through a soil matrix (cm ² /sec), from Equation 5-4
P _a	=	air filled porosity of the soil matrix, 0.284 (unitless) (Cal/EPA 1994)
K _{as}	=	soil-to-air partition coefficient (g soil/cm ³ air), from Equation 5-5
UC1	=	unit conversion factor (0.0001 m ² /cm ²)

The dispersion coefficient, Q/C, was calculated using the following equation:

$$Q/C = \{ \exp[((0.1004 \times \ln(A)) - 5.3466) + (2.92 \times sY)] \}^{-1} \quad (5-2)$$

where

A	=	assumed area of contiguous contamination, 484 m ² (Cal/EPA 1994)
sY	=	intermediate value for calculating Q/C, derived as follows:

$$0.02685 \times \{ 0.25 + [(\ln(A) - 11.0509)^2 / 26.3608] \} \quad (5-3)$$

The effective diffusivity of the COPC through the soil matrix, D_{ei}, was estimated by:



$$D_{ei} = D_i \times (P_a^{3.33}/P_t^2) \quad (5-4)$$

where

- D_i = COPC-specific diffusivity of COPC in air (cm^2/sec), from Table 5-3
 P_a = air filled porosity of soil matrix, 0.284 (unitless) (Cal/EPA 1994)
 P_t = total porosity of soil matrix, 0.434 (unitless) (Cal/EPA 1994)

The soil-to-air partition coefficient, K_{as} , was derived from the COPC-specific soil-water partition coefficient and Henry's Law constant:

$$K_{as} = H/(R \times T \times K_{oc}) \quad (5-5)$$

where

- H = COPC-specific Henry's Law constant ($\text{atm-m}^3/\text{mol}$), from Table 5-3
 R = ideal gas constant, $8.206 \times 10^{-5} \text{ atm-m}^3/\text{mol/K}$
 T = temperature in Kelvin, 293 K
 K_{oc} = soil-to-water partitioning coefficient (cm^3/g), from Table 5-3

The intermediate conversion factor, Z , in the volatilization attenuation factor was calculated as:

$$Z = (D_{ei} \times P_a) / [P_a + (ps \times (1 - P_a) / K_{as})] \quad (5-6)$$

where

- D_{ei} = effective diffusivity of a COPC through a soil matrix (cm^2/sec)
 P_a = air filled porosity of the soil matrix, 0.284 (unitless) (Cal/EPA 1994)
 ps = true soil or particle density, 1.5 g/cm^3 (Cal/EPA 1994)
 K_{as} = soil-to-air partition coefficient ($\text{g soil/cm}^3 \text{ air}$)

A summary of the calculated volatilization attenuation factors is presented in Table 5-4.



TABLE 5-3
COPC-SPECIFIC CONSTANTS

COPC	Henry's Law Constant, H' (atm-m ³ /mol)	Henry's Law Constant, H (unitless)	Organic Partitioning Coefficient, K _{oc} (cm ³ /g)	Diffusivity Coefficient, D _i (cm ² /s)
1,1-dichloroethene	1.54E-01	6.41E+00	6.50E+01	1.01E-01
1,2,4-trimethylbenzene	6.16E-03	2.56E-01	2.71E+03	6.42E-02
1,3,5-trimethylbenzene	5.71E-03	2.37E-01	6.61E+02	6.63E-02
aroclor 1248	NV	NV	NV	NV
<u>aroclor 1254</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
aroclor 1260	NV	NV	NV	NV
<u>arsenic</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
benzo(a)anthracene	NV	NV	NV	NV
benzo(a)pyrene	NV	NV	NV	NV
benzo(b)fluoranthene	NV	NV	NV	NV
<u>benzo(k)fluoranthene</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
bis(2-ethylhexyl)phthalate	NV	NV	NV	NV
chrysene	NV	NV	NV	NV
dibenzo(a,h)anthracene	NV	NV	NV	NV
fluoranthene	NV	NV	NV	NV
<u>indeno(1,2,3-cd)pyrene</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
naphthalene	NV	NV	NV	NV
n-butylbenzene	1.25E-02	5.20E-01	2.46E+03	5.80E-02
n-propylbenzene	1.00E-02	4.16E-01	7.41E+02	6.40E-02
p-cymene	1.10E-02	4.58E-01	1.26E+04	6.20E-02
phenanthrene	NV	NV	NV	NV
pyrene	NV	NV	NV	NV
tetrachloroethylene	2.30E-02	9.57E-01	3.64E+02	7.40E-02
trichloroethene	8.90E-03	3.70E-01	1.26E+02	8.12E-02
xylene _s	6.30E-03	2.62E-01	8.54E+02	8.70E-02

NOTES:
NV = Not Volatile

SOURCE:
Electronic Handbook of Risk Assessment Values (EHP 1997)



TABLE 5-4
CALCULATED COPC-SPECIFIC
VOLATILIZATION ATTENUATION FACTORS (VF)

COPC	VF (m ³ /kg)
1,1-dichloroethene	2.07E+01
1,2,4-trimethylbenzene	1.79E+03
1,3,5-trimethylbenzene	8.99E+02
aroclor 1248	NV
<u>aroclor 1254</u>	<u>NV</u>
aroclor 1260	NV
<u>arsenic</u>	<u>NV</u>
benzo(a)anthracene	NV
benzo(a)pyrene	NV
benzo(b)fluoranthene	NV
<u>benzo(k)fluoranthene</u>	<u>NV</u>
bis(2-ethylhexyl)phthalate	NV
chrysene	NV
dibenzo(a,h)anthracene	NV
fluoranthene	NV
<u>indeno(1,2,3-cd)pyrene</u>	<u>NV</u>
naphthalene	NV
n-butylbenzene	1.26E+03
n-propylbenzene	7.29E+02
p-cymene	2.94E+03
phenanthrene	NV
pyrene	NV
tetrachloroethylene	3.02E+02
trichloroethene	2.72E+02
xlenes	8.50E+02

NV = Not Volatile



5.3.1.2 Particulate Resuspension Attenuation Factors

Estimating airborne concentrations of COPCs in the particulate phase involves modeling both resuspension and dispersion. The resuspension component was designed by Cowherd (1985) as a rapid assessment procedure applicable to a typical hazardous waste site where the surface contamination provides relatively continuous and constant potential for emission over a period of time. This component considers wind-borne emissions and does not consider dust emissions from traffic or other forms of mechanical disturbances. However, it is felt that the degree of accuracy attainable using this model is consistent with that generally expected to result from simplified quantitative estimation procedures (EPA 1986).

For the Parcel A analysis, the Gaussian dispersion component applied to volatile emissions (Section 5.3.1.1) was also applied to particulate dispersion.

The particulate resuspension attenuation factor, PF, was calculated as follows:

$$PF = Q/C \times \{3600/[RPF \times (1-G) \times (U_m/U_t)^3 \times F_x]\} \quad (5-7)$$

where

- PF = particulate attenuation factor (m³/kg)
Q/C = dispersion component, emission flux per unit concentration [(g/m²/sec)/(kg/m³)], from Equation 5-9
RPF = respirable fraction of particulate, 0.036 g/m²/h
G = fraction of vegetative cover, 0, assumed (unitless)
U_m = wind speed, 4.5 m/sec
U_t = equivalent threshold value of wind speed at 10 meters, 12.8 m/sec
F_x = function describing U_t/U_m (unitless), as follows:

$$F_x = 0.18 \times [8X^3 + 12X] \times \exp[-(X^2)] \quad (5-8)$$

where



$$X = 0.886 \times (U_t/U_m)$$

The dispersion coefficient, Q/C , was calculated using the following equation:

$$Q/C = \{ \exp[((0.1004 \times \ln(A)) - 5.3466) + (2.92 \times sY)] \}^{-1} \quad (5-9)$$

where

A = assumed area of contiguous contamination, 484 m² (Cal/EPA 1994)

sY = intermediate value for calculating Q/C , derived as follows:

$$0.02685 \times \{ 0.25 + [(\ln(A) - 11.0509)^2 / 26.3608] \} \quad (5-10)$$

As shown in the previous equations, the calculated particulate attenuation factor is independent of the COPC and represents an estimated rate of resuspension of soil. The calculated value used in this report is 4.77×10^9 m³/kg.

5.3.2 Commercial/Industrial Emissions Case (Non-Intrusive)

The commercial/industrial emissions case consists of two components: 1) air dispersion modeling (Section 5.3.2.1), to account for COPCs in the ambient air and 2) indoor air modeling (Section 5.3.2.2), to account for COPCs that may migrate into future site buildings. These analyses were conducted for each AOPC. Particulate emissions are not significant because of the projected clean-fill cover.

5.3.2.1 Air Dispersion Modeling

The latest release of the Industrial Source Complex - Short Term 3 (ISCST3) air dispersion model (EPA 1996b) was used to calculate maximum annual on- and off-site COPC concentrations. DTSC recommends this model for air pathway analysis at hazardous waste sites (Cal/EPA 1992). EPA developed the ISCST3 model to assess the air-quality impact of emissions



from a wide variety of sources. The model incorporates a steady-state Gaussian plume equation that is applicable in flat and gently rolling terrain and can be used for single- or multiple-point area or volume sources. ISCST3 can calculate short-term as well as annual average COPC concentrations at user-defined receptor locations. The required input to the model include source locations, configurations and emissions, receptor locations and elevations, and hourly meteorological data (the latter including wind speed, wind direction, atmospheric stability, ambient temperature, and mixing height).

Emission Estimates

As presented in Section 4.2.2, the primary release mechanism identified for COPC air emissions from soils is volatilization. As DTSC/HERD and Integrated have agreed (IESI 1998b), the groundwater sources underling these AOPCs are not anticipated to significantly contribute to air emissions, based on the depth to the first aquifer and the relatively low concentrations of constituents in the aquifer compared to the shallower soil sources.

Methods for estimating organic COPC emission rates from various hazardous waste media are provided in guidance documents from Cal/EPA (Cal/EPA 1990) and EPA (EPA 1987a, 1987b, 1988c, 1989a). The methods for estimating organic emissions from landfills without internal gas generation are applicable to AOPCs.

The landfill emission equation (without internal gas generation) is based on Frick's First Law of steady state diffusion and was developed by Farmer (Farmer et al. 1980). The Farmer model provides a worst-case estimate by assuming the soil is completely dry and the COPC concentration at the surface- soil/air interface is zero. These assumptions provide the largest soil vapor space for volatilization and the highest driving force for COPC flux from the soil. The Farmer model was modified by Shen (1981) to enable calculation of the volatilization of specific components of complete waste mixtures. The final equations used in the analysis for calculating organic COPC emissions from the AOPCs are presented below (EPA 1989a, 1989b, 1990a).



COPC concentrations in soil gas were estimated from each AOPC's representative soil concentrations:

$$C_{sg} = \frac{C_s HP_s}{[P_w + K_{oc} P_s + HP_a]} \quad (5-11)$$

where

C_{sg}	=	concentration in soil gas (mg/L)
C_s	=	representative concentration in soil (mg/kg), from Table 5-2
H	=	Henry's law constant (unitless), from Table 5-3
P_s	=	soil bulk density, 1.5 g/cm ³ (Cal/EPA 1994)
P_w	=	water filled porosity, 0.15 (Cal/EPA 1994)
K_{oc}	=	organic carbon partition coefficient (L/kg), from Table 5-3
P_a	=	air filled porosity, 0.284 (Cal/EPA 1994)

The estimated soil gas concentrations were used to calculate the diffusive flux of the COPC from soils to the atmosphere:

$$F = (C_{sg} - C_o) \times D_{ei} \times UC1 / X \quad (5-12)$$

where

F	=	flux (mg/cm ² -sec)
C_{sg}	=	concentration in soil gas (mg/L), from Equation 5-11
C_o	=	existing soil gas concentration, 0 mg/L, assumed for soil source estimation purposes
D_{ei}	=	effective diffusivity of a COPC through soil matrix (cm ² /sec)
$UC1$	=	unit conversion, 0.001 L/cm ³
X	=	effective depth of cover, 61 cm (soils)



The effective diffusivity, D_{ei} , of the COPC through the media between the source and atmosphere is approximated as:

$$D_{ei} = D_i \times (P_t(M \times B))^{3.33}/P_t^2 \quad (5-13)$$

where

- D_i = COPC-specific diffusivity of COPC in air (cm^2/sec), from Table 5-3
- P_t = total soil porosity, 0.434 (unitless) (Cal/EPA 1994)
- M = moisture content of soil, $0.15 \text{ cm}^3/\text{g}$ (Cal/EPA 1994)
- B = bulk density of soil, $1.50 \text{ g}/\text{cm}^3$ (Cal/EPA 1994)

It is important to note that site-specific conditions have indicated that transport is governed by diffusive forces. To maximize the estimated flux of COPCs from the AOPCs it has been assumed for each medium that the existing soil gas concentrations in the soil column is zero. Therefore, each AOPC is estimated at its maximum flux rate. The COPC flux rates from each AOPC used in this analysis are presented in Table 5-5.

Meteorological Data

ISCST3 requires as input meteorological data characterizing the transport and dispersion conditions of the study area. The SCAQMD has identified 1981 as one of the worst years for air dispersion (SCAQMD 1993) and therefore provided hourly meteorological data from that year for use in the ISCST3 model. The data were collected from the SCAQMD monitoring station nearest the C-6 facility, Hawthorne/Lennox. Figure 5-2 shows frequency distributions of wind speed and direction at the Hawthorne/Lennox site.

Receptors

A rectangular grid over Parcel A was used for air dispersion analysis (Figure 5-3). The grid covers the entire site with a grid-point interval of 100 feet and is large enough to show the



maximum off-site impact for each COPC. Additional discrete receptor points have been located along the northern boundary of the residential development to the south of the Boeing property. These receptors have been used to estimate maximum off-site residential exposure concentrations. The flagpole receptor option in the ISCST3 model was used to place the grid points 1.5 meters above the ground—the approximate breathing height of a typical adult.

TABLE 5-5
COPC FLUX RATES BY SOURCE (mg/cm² sec)

COPC	AOPC 1	AOPC 2
1,1-dichloroethene	3.51E-08	8.75E-08
1,2,4-trimethylbenzene	3.68E-11	1.83E-10
1,3,5-trimethylbenzene	1.07E-10	3.18E-10
aroclor 1248	NV	NV
<u>aroclor 1254</u>	<u>NV</u>	<u>NV</u>
aroclor 1260	NV	NV
<u>arsenic</u>	<u>NV</u>	<u>NV</u>
benzo(a)anthracene	NV	NV
benzo(a)pyrene	NV	NV
benzo(b)fluoranthene	NV	NV
<u>benzo(k)fluoranthene</u>	<u>NV</u>	<u>NV</u>
bis(2-ethylhexyl)phthalate	NV	NV
chrysene	NV	NV
dibenzo(a,h)anthracene	NV	NV
fluoranthene	NV	NV
<u>indeno(1,2,3-cd)pyrene</u>	<u>NV</u>	<u>NV</u>
naphthalene	NV	NV
n-butylbenzene	4.77E-11	9.70E-11
n-propylbenzene	1.36E-10	3.12E-10
p-cymene	8.24E-12	1.80E-11
phenanthrene	NV	NV
pyrene	NV	NV
tetrachloroethylene	7.32E-10	1.06E-09
trichloroethene	8.74E-10	3.35E-09
xylene _s	9.11E-11	1.91E-10

NV = Not Volatile

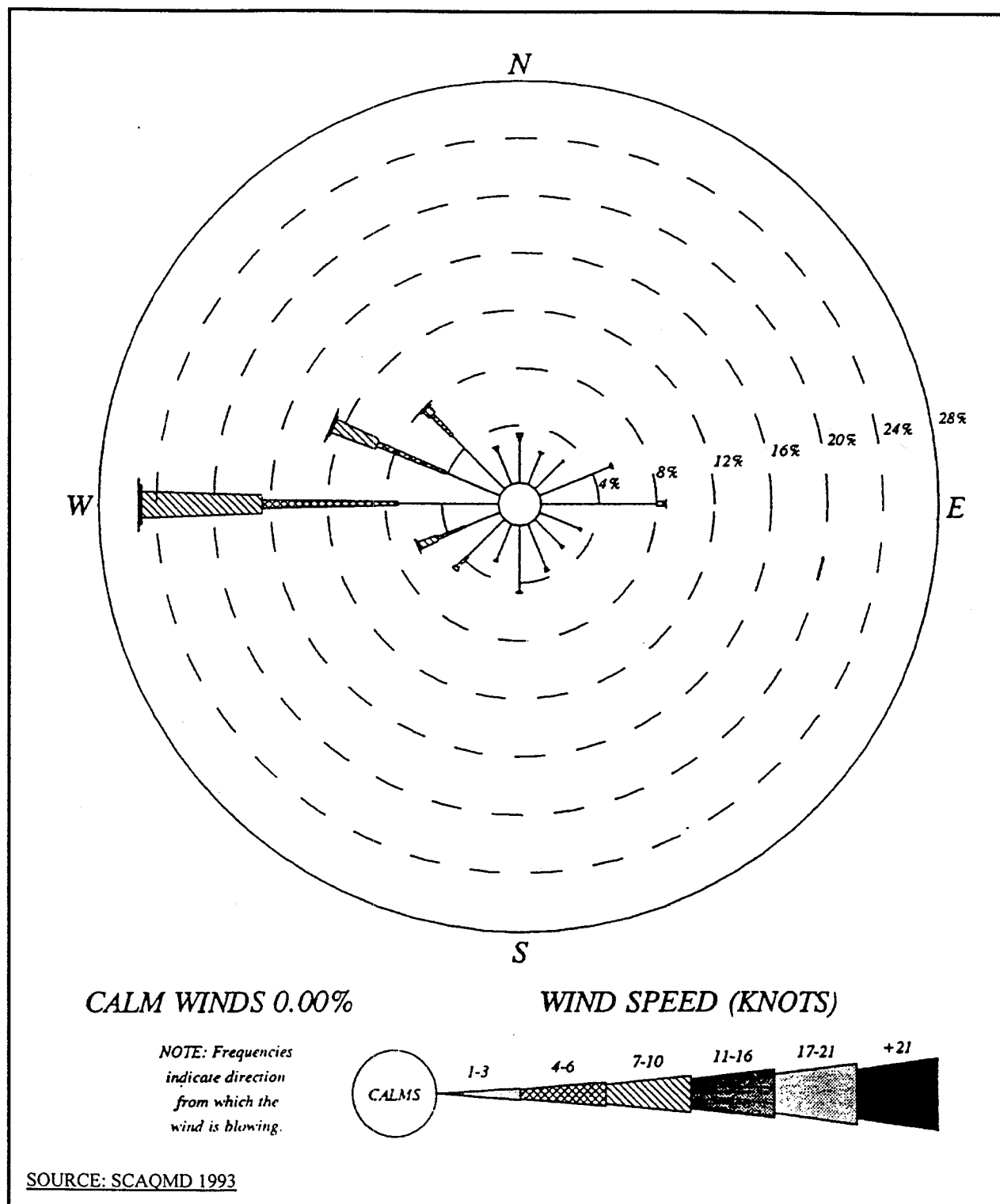


FIGURE 5-2
WIND ROSE FOR SCAQMD HAWTHORNE/LENNOX SITE



4.2.2 Release Mechanisms

The COPC sources discussed above can be divided conceptually into two categories: 1) direct sources, such as surface soils, which are readily available for potential receptor exposures, and 2) indirect sources, such as groundwater and subsurface soil, which are not readily available for receptor exposure and require an intermediate release and transport mechanism before receptors can be exposed. The mechanisms for COPC release and transport for indirect sources are:

- Groundwater flow
- Leaching
- Volatilization
- Dust and particulate emissions

COPC migration by the way of groundwater flow depends on the properties of the COPC, aquifer geology, and groundwater velocity. The solubility and organic carbon partition coefficient (K_{OC}) effect the transport of organic constituents in the groundwater. Organic constituents tend to flow in the direction of the groundwater but at a slower rate. This is because organic constituents moving with the groundwater tend to partition or divide themselves between the mobile water phase and the stationary soil particles that are in contact with groundwater (i.e., the process of adsorption). The overall effect of this sorption process is to retard the COPC's rate of transport. Retardation increases the travel time for the bulk of the COPC plume to reach the receptor.

COPCs can also be released to the groundwater from subsurface sources (e.g., surface soil and subsurface soil) as a result of leaching. Precipitation infiltrating the source media initiates the release of COPCs from the soil into the downward migrating water. As the infiltrating water moves toward the underlying groundwater, the COPCs are subjected to many of the same forces discussed above. Transport time from source to groundwater is highly dependent upon additional conditions, including infiltration volume, surface structures, frequency of precipitation, depth from source to groundwater, and soil properties.



Chemical composition, molecular weight, solubility, and viscosity also influence COPC migration. In general, constituents that are highly soluble in water are considered mobile in groundwater. Table 4-1 gives the mobility of the Parcel A COPCs. Those with high water solubilities (greater than 1000 ppm) and low K_{OC} values (less than 150) are considered very mobile in water. Those COPCs exhibiting low mobility, based on their solubility and K_{OC} values, would not be expected to move readily in groundwater or leach into groundwater.

Volatilization is the mass transfer of an organic constituent from a specific medium (e.g., soil or groundwater) to air. Vapor from volatile constituents moves in the subsurface soil away from the source toward the atmosphere. Environmental factors that effect volatilization include temperature, soil porosity, soil moisture content, soil organic carbon content, depth to contamination, and surface structures. The volatility of a constituent is a function of its vapor pressure, water solubility, and air diffusion coefficient. Among constituents with similar vapor pressures, those with high water solubilities are less likely to become volatile than those with lower solubilities. Generally, constituents with high vapor pressures (greater than 10 mm Hg) or high Henry's Law constants (greater than 10^{-3} atm-3/mol) can be expected to volatilize readily from water and soil (Cal/EPA 1994). Table 4-2 lists the COPCs at Parcel A that are expected to volatilize readily.

Dust and soil particulate emissions can result from wind and mechanical erosion (e.g., construction activities). Environmental factors that influence wind erosion are wind speed, moisture content, vegetative cover, soil composition, and surface structures. Chemical and physical properties can also be used to estimate a constituent's potential to be emitted in dust. Constituents with relatively high organic carbon partition coefficients (K_{OC} greater than 2000) are more likely to be associated with soil and thus are likely to be sorbed on dust or soil particulate (EPA 1988c). The Parcel A COPCs that will more likely be found in dust and soil particulate are listed in Table 4-3.



TABLE 4-1
COPC MOBILITY IN WATER

COPC	CAS No.	Water Solubility (ppm)	Water Solubility Ref.	K _{oc} (mL/g)	K _{oc} Ref.	Mobile ?
1,1-dichloroethene	75-35-4	2.25E+03	EPA 1984h	6.50E+01	Mabey 1982	Yes
1,2,4-trimethylbenzene	95-63-6	5.70E+01	McAuliffe 1966	2.71E+03	SRC 1988	No
1,3,5-trimethylbenzene	108-67-8	9.77E+01	Chiou 1982	6.61E+02	Schwarz'h 1981	No
aroclor 1248	12672-29-6	2.00E-01	Mackay 1983	2.77E+05	Mabey 1982	No
<u>aroclor 1254</u>	<u>11091-69-1</u>	<u>4.10E-02</u>	<u>Mabey 1982</u>	<u>2.14E+06</u>	<u>Mabey 1982</u>	<u>No</u>
aroclor 1260	11096-82-5	1.44E-02	Mabey 1982	6.70E+06	Mabey 1982	No
<u>arsenic</u>	<u>7440-38-2</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>	<u>No</u>
benzo(a)anthracene	56-55-3	1.40E-02	Mabey 1982	1.38E+06	Lyman 1982c	No
benzo(a)pyrene	50-32-8	5.00E-05	Mackay 1977	5.50E+06	Mabey 1982	No
benzo(b)fluoranthene	205-99-2	1.40E-02	Mabey 1982	5.50E+05	Mabey 1982	No
<u>benzo(k)fluoranthene</u>	<u>207-08-9</u>	<u>4.30E-03</u>	<u>Lee 1981</u>	<u>5.50E+05</u>	<u>Mabey 1982</u>	<u>No</u>
bis(2-ethylhexyl)phthalate	117-81-7	4.00E-01	McDuffie 1984	8.74E+04	Russell 1986	No
chrysene	218-01-9	2.00E-03	Lee 1981	2.00E+05	Mabey 1982	No
dibenzo(a,h)anthracene	53-70-3	1.40E-02	Callahan 1979	3.30E+06	Mabey 1982	No
fluoranthene	206-44-0	2.60E-01	Lee 1981	3.80E+04	Mabey 1982	No
<u>indeno(1,2,3-cd)pyrene</u>	<u>193-39-5</u>	<u>5.30E-04</u>	<u>Lee 1981</u>	<u>1.60E+06</u>	<u>Mabey 1982</u>	<u>No</u>
naphthalene	91-20-3	3.17E+01	Lee 1981	9.40E+03	Mabey 1982	No
n-butylbenzene	104-51-8	5.00E+01	Mabey 1982	2.46E+03	SRC 1988	No
n-propylbenzene	103-65-1	6.02E+01	Lee 1981	7.41E+02	Mabey 1982	No
p-cymene	99-87-6	2.34E+01	Lee 1981	1.26E+04	Mabey 1982	No
phenanthrene	85-01-8	1.29E+00	Lee 1981	1.40E+04	Mabey 1982	No
pyrene	129-00-0	1.35E-01	Lee 1981	3.80E+04	Mabey 1982	No
tetrachloroethylene	127-18-4	4.84E+02	Banerjee 1980	3.64E+02	Mabey 1982	No
trichloroethene	79-01-6	1.47E+03	Banerjee 1980	1.26E+02	Mabey 1982	Yes
xylene	1330-20-7	2.00E+02	Chiou 1982	8.54E+02	Mabey 1982	No

NA = Not Available

SOURCE (Water Solubility and K_{oc}):
Electronic Handbook of Risk Assessment Values (EHP 1997)



TABLE 4-2
VOLATILITY OF COPCs

COPC	CAS No.	Vapor Pressure (mm Hg)	Vapor Pressure Ref.	Henry's Law Constant (atm-m ³ /mol)	Henry's Law Constant Ref.	Volatile ?
1,1-dichloroethene	75-35-4	6.00E+02	EPA 1984h	1.54E-01	Mackay 1981	Yes
1,2,4-trimethylbenzene	95-63-6	2.10E+00	Chao 1983	6.16E-03	Salee 1984	Yes
1,3,5-trimethylbenzene	108-67-8	1.86E+00	Browning 1965	5.71E-03	Mackay 1981	Yes
aroclor 1248	12672-29-6	1.80E-04	Foreman 1985	4.40E-04	Burkhard 1985	No
<u>aroclor 1254</u>	<u>11091-69-1</u>	<u>4.30E-05</u>	<u>Foreman 1985</u>	<u>2.00E-04</u>	<u>Murphy 1987</u>	<u>No</u>
aroclor 1260	11096-82-5	1.10E-05	Murphy 1987	2.50E-04	Murphy 1987	No
<u>arsenic</u>	<u>7740-38-2</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>	<u>No</u>
benzo(a)anthracene	56-55-3	2.10E-06	Sonnefeld 1983	4.50E-06	EHP 1997*	No
benzo(a)pyrene	50-32-8	5.60E-09	Yamasaki 1984	3.72E-05	EHP 1997*	No
benzo(b)fluoranthene	205-99-2	5.00E-07	Mabey 1982	1.18E-05	EHP 1997*	No
<u>benzo(k)fluoranthene</u>	<u>207-08-9</u>	<u>5.10E-07</u>	<u>Mabey 1982</u>	<u>3.94E-05</u>	<u>EHP 1997*</u>	<u>No</u>
bis(2-ethylhexyl)phthalate	117-81-7	2.00E-07	Mabey 1982	4.40E-07	Wolfe 1980	No
chrysene	218-01-9	6.40E-09	Yamasaki 1984	9.60E-07	EHP 1997*	No
dibenzo(a,h)anthracene	53-70-3	1.00E-10	Mabey 1982	6.85E-08	EHP 1997*	No
fluoranthene	206-44-0	9.20E-06	Sonnefeld 1983	9.41E-06	EHP 1997*	No
<u>indeno(1,2,3-cd)pyrene</u>	<u>193-39-5</u>	<u>1.00E-10</u>	<u>Mabey 1982</u>	<u>6.85E-08</u>	<u>EHP 1997*</u>	<u>No</u>
naphthalene	91-20-3	7.80E-02	Sonnefeld 1983	4.20E-04	Mackay 1981	No
n-butylbenzene	104-51-8	1.03E+00	Hine 1975	1.25E-02	Mackay 1981	Yes
n-propylbenzene	103-65-1	2.50E+00	Hine 1975	1.00E-02	Mackay 1981	Yes
p-cymene	99-87-6	1.46E+00	Mabey 1982	1.10E-02	Wolfe 1980	Yes
phenanthrene	85-01-8	1.20E-04	Sonnefeld 1983	3.90E-05	Mackay 1981	No
pyrene	129-00-0	4.50E-06	Sonnefeld 1983	8.86E-06	EHP 1997*	No
tetrachloroethylene	127-18-4	1.85E+01	Hine 1975	2.30E-02	Mackay 1981	Yes
trichloroethene	79-01-6	7.43E+01	Hine 1975	8.90E-03	Mackay 1981	Yes
xylene	1330-20-7	6.69E+00	Hine 1975	6.30E-03	Mackay 1981	Yes

NOTES:

*Calculated as follows: Henry's Law Constant = VP/WSol,
where VP = Vapor in atmospheres (atm) and WSol = Water Solubility in moles/m³ (EHP 1997).
NA = Not Available

SOURCE (Vapor Pressure and Henry's Law Constant):
Electronic Handbook of Risk Assessment Values (EHP 1997)



TABLE 4-3
COPC ADSORPTION TO SOIL PARTICLES

COPC	CAS No.	K _{oc} (mL/g)	K _{oc} Ref.	Absorbed ?
1,1-dichloroethene	75-35-4	6.50E+01	Mabey 1982	No
1,2,4-trimethylbenzene	95-63-6	2.71E+03	SRC 1988	Yes
1,3,5-trimethylbenzene	108-67-8	6.61E+02	Schwarz'h 1981	No
aroclor 1248	12672-29-6	2.77E+05	Mabey 1982	Yes
<u>aroclor 1254</u>	<u>11091-69-1</u>	<u>2.14E+06</u>	<u>Mabey 1982</u>	<u>Yes</u>
aroclor 1260	11096-82-5	6.70E+06	Mabey 1982	Yes
<u>arsenic</u>	<u>7440-38-2</u>	<u>NA</u>	<u>NA</u>	<u>No</u>
benzo(a)anthracene	56-55-3	1.38E+06	Lyman 1982c	Yes
benzo(a)pyrene	50-32-8	5.50E+06	Mabey 1982	Yes
benzo(b)fluoranthene	205-99-2	5.50E+05	Mabey 1982	Yes
<u>benzo(k)fluoranthene</u>	<u>207-08-9</u>	<u>5.50E+05</u>	<u>Mabey 1982</u>	<u>Yes</u>
bis(2-ethylhexyl)phthalate	117-81-7	8.74E+04	Russell 1986	Yes
chrysene	218-01-9	2.00E+05	Mabey 1982	Yes
dibenzo(a,h)anthracene	53-70-3	3.30E+06	Mabey 1982	Yes
fluoranthene	206-44-0	3.80E+04	Mabey 1982	Yes
<u>indeno(1,2,3-cd)pyrene</u>	<u>193-39-5</u>	<u>1.60E+06</u>	<u>Mabey 1982</u>	<u>Yes</u>
naphthalene	91-20-3	9.40E+02	Mabey 1982	No
n-butylbenzene	104-51-8	2.46E+03	Mabey 1982	Yes
n-propylbenzene	103-65-1	7.41E+02	Mabey 1982	No
p-cymene	99-87-6	1.26E+04	Mabey 1982	Yes
phenanthrene	85-01-8	1.40E+04	Mabey 1982	Yes
pyrene	129-00-0	3.80E+04	Mabey 1982	Yes
tetrachloroethylene	127-18-4	3.64E+02	Mabey 1982	No
trichloroethene	79-01-6	1.26E+02	Mabey 1982	No
xylenes	1330-20-7	8.54E+02	Mabey 1982	No

NA = Not Available

SOURCE (K_{oc}):
Electronic Handbook of Risk Assessment Values (EHP 1997)



4.2.3 Significant Exposure Pathways

Not all release mechanisms lead to significant exposure pathways under the Parcel A exposure scenarios. This section discusses the significance of each exposure pathway considered at the onset of the risk assessment and gives the rationale for the inclusion or exclusion of each in the final determination of risk. Figure 4-1 summarizes the identified significant pathways at Parcel A and their relationships to the previously discussed contamination sources.

4.2.3.1 Inhalation Exposure Pathways

Exposures via the inhalation pathways consist of COPCs transported by air eventually reaching a receptor who inhales airborne vapor, gases, and/or suspended particulate. The following inhalation pathways were reviewed for inclusion in this risk assessment:

- Inhalation of gas and suspended particulate in outdoor air
- Inhalation of gases and particulate migrating from outdoor to indoor air
- Inhalation of soil vapor that migrates to indoor air
- Inhalation of COPCs released during tap water usage

With the exception of the inhalation of COPCs released from tap water, all inhalation exposure pathways are included in this risk assessment. The tap water pathway was excluded since Parcel A will receive all water from a municipal source. In addition, groundwater characteristics (i.e., quality and yield) are not suitable for domestic use, and deed restrictions will be in place restricting its use. Furthermore, the groundwater is not a significant source of volatile emissions due to its depth and relatively low COPC concentrations when compared to shallower soil sources (IESI 1998b).

4.2.3.2 Dermal Contact Exposure Pathways

This group of pathways encompasses all receptor activities that result in direct contact with soil or groundwater containing COPCs. The following dermal contact exposure pathways were reviewed for inclusion in this risk assessment:



- Dermal contact with surface soils
- Dermal contact with groundwater in baths and showers

Deed restrictions on Parcel A will limit development to commercial/industrial uses. In addition, all water will be supplied by a local municipality; therefore, dermal exposure to groundwater is not a reasonable possibility. Dermal exposure to surface soils is further evaluated in this risk assessment.

4.2.3.3 Ingestion Exposure Pathways

These exposure pathways include the most likely routes by which a receptor may incidentally ingest COPCs originating from Parcel A. The following ingestion exposure pathways were reviewed for inclusion in this risk assessment:

- Ingestion of fruits, vegetables, and grains containing COPCs due to atmospheric exposure
- Ingestion of meat, milk, and eggs containing COPCs due to atmospheric exposure of the livestock feed source
- Ingestion of meat, milk, and eggs containing COPCs due to livestock inhalation exposures
- Incidental ingestion of soil containing COPCs
- Ingestion of fruits, vegetables, and grains grown in soil containing COPCs
- Ingestion of meat, milk, and eggs containing COPCs due to livestock consumption of feed grown in soil containing COPCs
- Ingestion of meat, milk, and eggs containing COPCs due to incidental ingestion by livestock during feeding
- Ingestion of fruits, vegetables, and grains containing COPCs due to irrigation with groundwater
- Ingestion of meat, milk, and eggs containing COPCs due to livestock consumption of feed irrigated with groundwater
- Ingestion of meat, milk, and eggs containing COPCs due to livestock consumption of groundwater

Deed restrictions will preclude all agricultural development; development is limited to commercial/industrial uses. Thus, all agriculturally based exposure pathways are not applicable.



The incidental ingestion of soil associated with receptor activity patterns will be evaluated further in this risk assessment.

4.2.4 Potentially Exposed Populations

Persons who work at or live near parcel A are the most likely to be exposed to its residual COPCs. To provide worst-case risk estimates for planning and comparison purposes, this risk assessment evaluates the potential health effects to five RME receptors: on-site commercial/industrial worker, on-site construction worker, off-site commercial/industrial worker, and off-site residents (adult and child).

In addition to these RME receptors, a sixth receptor is evaluated to address a possible "upper-bound" exposure scenario for the commercial/industrial worker. Because the layer of clean, imported fill material had not yet been placed on Parcel A at the time of this printing, two commercial/industrial worker exposures are evaluated: the RME, which assumes the layer of clean fill is in place, and the upper bound, which assumes no layer. The use of two cases is intended to "bracket" the anticipated risks associated with residual COPCs on the parcel. By comparing the two commercial/industrial worker cases, risk managers will be able to ascertain how well the layer reduces risk.

It is important to note if the associated risks to the proposed receptors are acceptable, then other, lesser exposures (e.g., recreational) are also acceptable. Receptors were chosen to ensure that the estimated risk values protect human health and that the actual risks do not exceed the predicted values. The development and selection of these receptors are based on the RME concept discussed in Section 4.1.3 and discussions with DTSC/HERD (IESI 1998b).

Descriptions of the types, locations, and lifestyles of these populations are provided below.



4.2.4.1 On-Site RME Construction Worker

This RME receptor represents the full-time employees of the construction firms contracted to develop and maintain the commercial/industrial facility. The construction worker is assumed to work on site 8 hours a day, 5 days a week. Three significant exposure pathways are applicable to this receptor under the construction scenario:

- Inhalation of volatilized COPCs and resuspended particulate (ambient air)
- Incidental ingestion of soil
- Dermal contact with soil

Ingestion of groundwater drawn from the underlying aquifer is not applicable to this receptor since all on-site water needs during construction will be provided by the local municipality or off-site sources. The inhalation of vapors originating from the underlying aquifer is not anticipated to be significant based on the depth to the aquifer and the concentration of constituents relative to shallower soil sources (IESI 1998b).

4.2.4.2 On-Site Commercial/Industrial Worker, RME Case

This RME receptor represents the full-time employees of the commercial/industrial facilities developed at Parcel A and is assumed to work on site 8 hours a day, 5 days a week (patrons or others visiting or conducting brief business at the site would have lesser exposures). Two significant exposure pathways are applicable to this receptor under the commercial/industrial scenario:

- Inhalation of gases and particulate that migrate from outdoor to indoor air
- Inhalation of soil vapor that migrates to indoor air

Because of the proposed commercial/industrial land use, deed restrictions, abovegrade landscaping and pavement—as well as the use of at least 2 feet of clean, imported soil as cover—this receptor's direct exposure to soils would require intrusive activities. Such intrusive exposures are often associated with maintenance activities or construction and are assessed as part of the on-site RME construction worker.



Ingestion of groundwater drawn from the underlying aquifer is not applicable to this receptor since all on-site commercial/industrial water needs will be provided by the local municipality. As agreed to by DTSC/HERD (IESI 1998b), the inhalation of vapors originating from the underlying aquifer is not anticipated to be significant based on the depth to the aquifer and the concentration of constituents relative to soil sources.

This receptor establishes the RME case under the assumption that the layer of clean, imported fill material is in place.

4.2.4.3 On-Site Commercial/Industrial Worker, Upper-Bound Case

As mentioned, a modified version of the commercial/industrial receptor has also been evaluated, at the request of DTSC. The key modification includes direct exposure to soils through frequent (125-day-per-year), long-term (25-year), intrusive activities. Direct exposure is made possible by assuming that no layer of fill will be placed on site. Under these conditions, the modified receptor establishes a reasonable upper-bound estimate of risk. It is important to note that once the fill material is in place, the risk estimated by this receptor will be greater than that posed by the site. This is consistent with an upper-bound approach.

This receptor represents the full-time employees of the commercial/industrial facilities developed at Parcel A and is assumed to work on site 8 hours a day (4 inside, 4 outside), 5 days a week. Under this modified commercial/industrial scenario, five significant exposure pathways are applicable to this receptor:

- Inhalation of gases and particulate in outdoor air
- Inhalation of gases that migrate from outdoor to indoor air
- Inhalation of soil vapor that migrates to indoor air
- Incidental ingestion of soils
- Dermal contact with soil

Ingestion of groundwater drawn from the underlying aquifer is not applicable to this receptor since all on-site commercial/industrial water needs will be provided by the local municipality.



The inhalation of vapors originating from the underlying aquifer is not anticipated to be significant based on the depth to the aquifer and the concentration of constituents relative to soil sources (IESI 1998b).

4.2.4.4 Off-Site RME Commercial/Industrial Worker

This RME receptor represents the full-time employees of the surrounding commercial/industrial facilities, as well as patrons or others who could be exposed while visiting or conducting brief business at these businesses. The off-site commercial/industrial worker is assumed to work 8 hours a day, 5 days a week. The significant exposure pathway for this receptor under this scenario is the inhalation of volatilized COPCs.

4.2.4.5 Off-Site RME Resident Adult

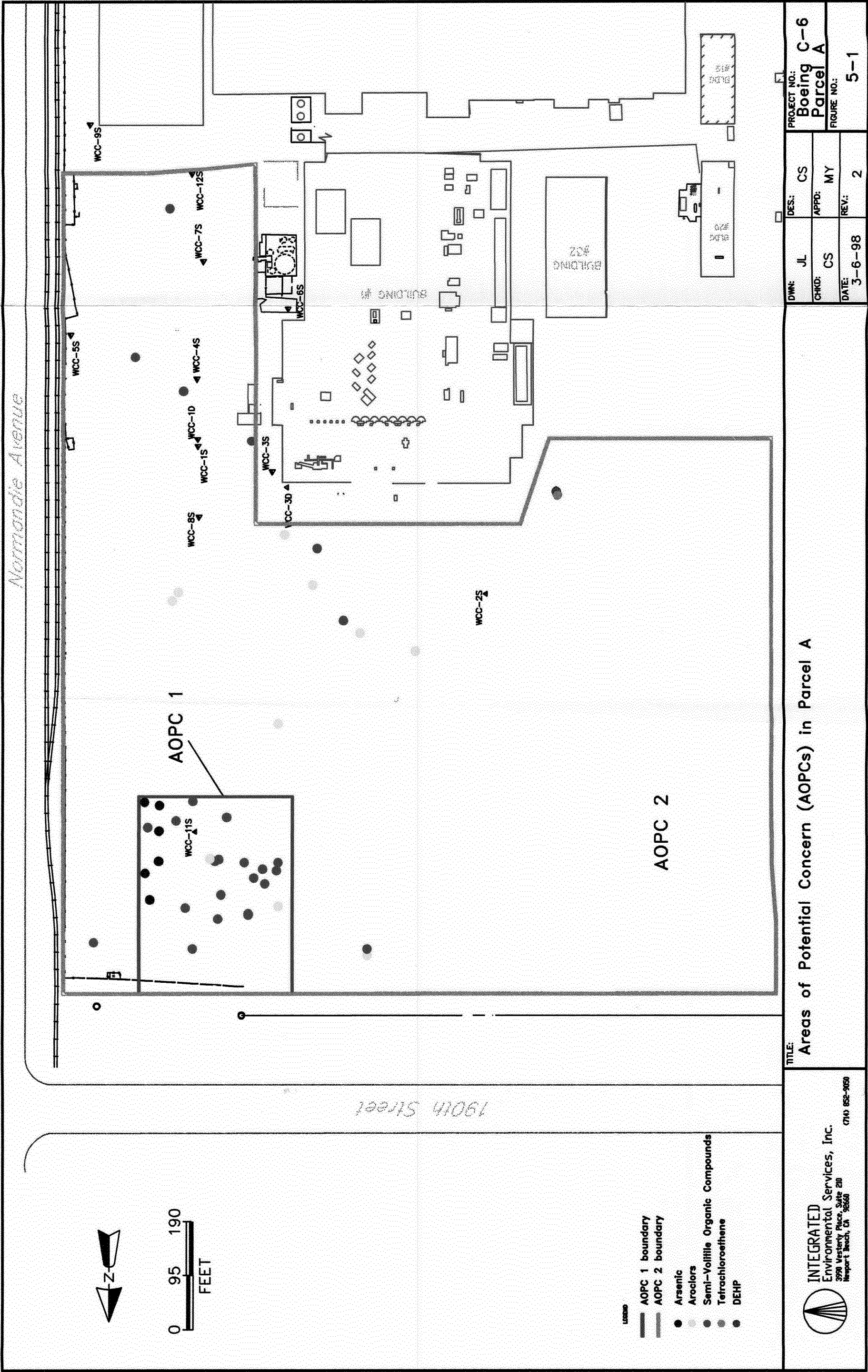
This RME receptor is assumed to reside south of Parcel A and at the modeled point of maximum air COPC concentration. Ingestion of groundwater drawn from the underlying Gage aquifer is not applicable to this receptor since all residential water needs are provided by the local municipality or off-site sources.

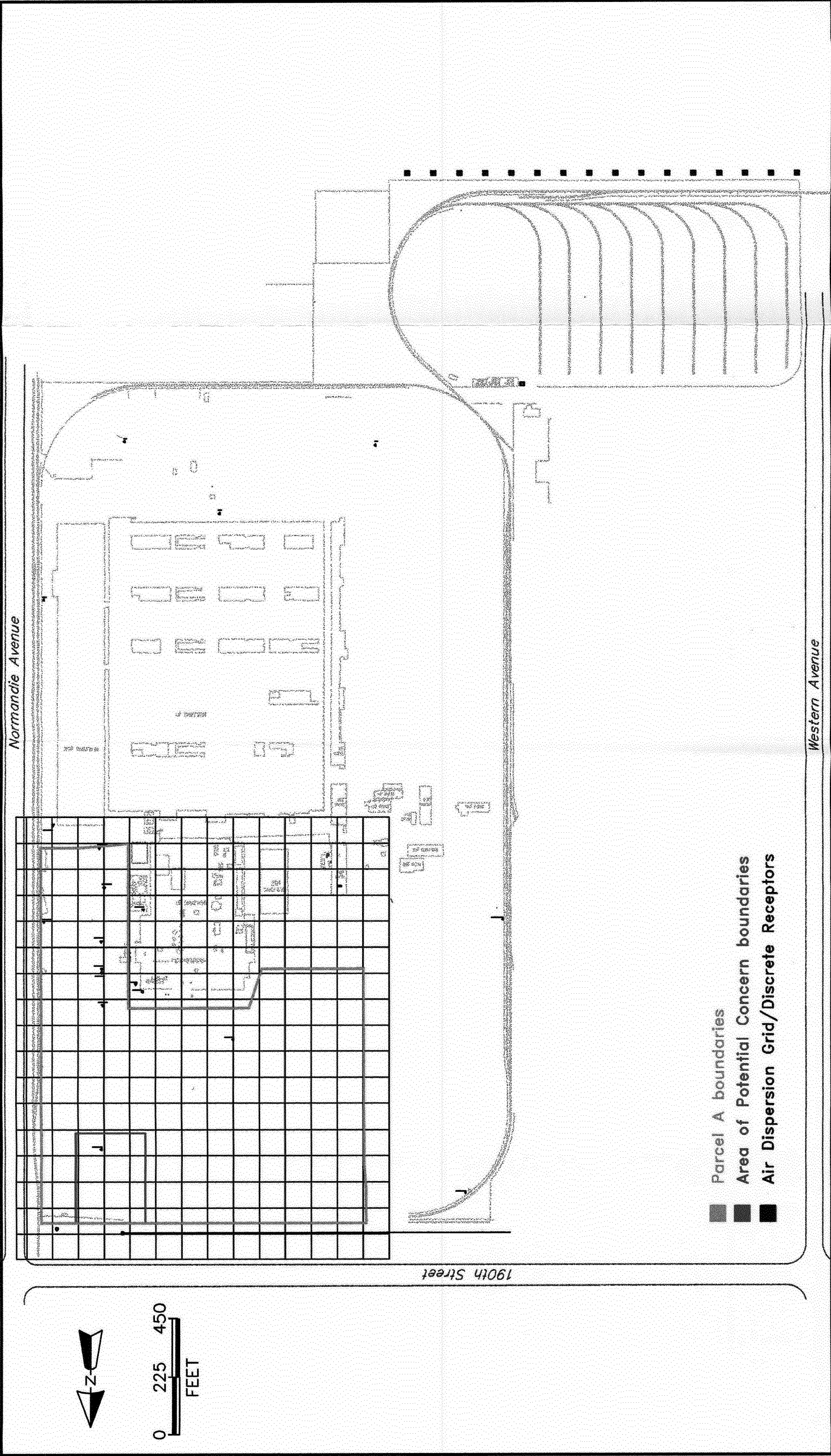
The significant receptor exposure pathway identified under this scenario is the inhalation of volatilized COPCs.

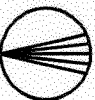
4.2.4.6 Off-Site RME Resident Child

Young children (ages 1 through 6) living in the vicinity of Parcel A form a population of concern because they may be more sensitive to a given exposure than are adults (i.e., noncarcinogenic exposures). For this post-demolition risk assessment, this RME receptor, like his parents, is assumed to reside south of Parcel A at the modeled point of maximum air COPC concentration.

The significant exposure pathway for this receptor under this scenario is the inhalation of volatilized COPCs.





 INTEGRATED Environmental Services, Inc. 3991 Westlark Place, Suite 200 Newport Beach, CA 92660 (714) 852-9650	TITLE: Grid System Used in Parcel A Air Dispersion Modeling		DWN: JL		DES: CS		PROJECT NO.: Boeing C-6 Parcel A	
			CHKD: CS		APPD: MY			
			DATE: 3-6-98		REV: 2		FIGURE NO.: 5-3	



Air Dispersion Modeling Results

The ISCST3 results for the maximum on- and off-site COPC, concentrations in air are summarized in Table 5-6. The modeling output files are provided in Appendix A.

TABLE 5-6
MODELED MAXIMUM ON-SITE AND OFF-SITE
COPC CONCENTRATIONS IN AIR (mg/m³)

COPC	Maximum On-Site Concentration	Maximum Off-Site Concentration	Maximum Residential Concentration
1,1-dichloroethene	1.24E-02	6.57E-03	3.65E-05
1,2,4-trimethylbenzene	2.38E-05	7.04E-06	3.83E-08
1,3,5-trimethylbenzene	4.37E-05	2.01E-05	1.11E-07
aroclor 1248	NV	NV	NV
<u>aroclor 1254</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
aroclor 1260	NV	NV	NV
<u>arsenic</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
benzo(a)anthracene	NV	NV	NV
benzo(a)pyrene	NV	NV	NV
benzo(b)fluoranthene	NV	NV	NV
<u>benzo(k)fluoranthene</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
bis(2-ethylhexyl)phthalate	NV	NV	NV
chrysene	NV	NV	NV
dibenzo(a,h)anthracene	NV	NV	NV
fluoranthene	NV	NV	NV
<u>indeno(1,2,3-cd)pyrene</u>	<u>NV</u>	<u>NV</u>	<u>NV</u>
naphthalene	NV	NV	NV
n-butylbenzene	1.43E-05	8.09E-06	4.96E-08
n-propylbenzene	4.48E-05	2.54E-05	1.41E-07
p-cymene	2.18E-06	4.07E-07	8.57E-10
phenanthrene	NV	NV	NV
pyrene	NV	NV	NV
tetrachloroethylene	1.70E-04	1.36E-04	7.61E-07
trichloroethene	4.46E-04	1.66E-04	9.09E-07
xylene	2.79E-05	1.70E-05	9.47E-08

NV = Not Volatile



5.3.2.2 Indoor Air Modeling

A review of vapor intrusion models was conducted to identify an appropriate model for estimating potential indoor air concentrations resulting from COPCs that may volatilize from soil and enter future buildings at each of the four AOPCs. The models estimate the constituent concentration in soil gas, the subsequent movement of the vapor phase constituent upward to the atmosphere, and then the concentration of the constituent in indoor air. The two models most appropriate for the Parcel A site conditions, Daugherty (Orange County) and Johnson-Ettinger, were compared using site-specific data. Based on this comparison, both models appear to be very conservative. However, under agreement with DTSC/HERD, the Johnson-Ettinger model was selected for indoor air analysis in this risk assessment.

The Johnson-Ettinger intrusion model incorporates several fundamental assumptions (Johnson and Ettinger 1991). The model considers both diffusive flux and convection driven flow. The constituent is assumed to be present as a non-diminishing, steady-state source even though, for most constituents, biodegradation and other attenuation forces are expected to occur in subsurface soils over time. This is therefore a conservative assumption. The system is assumed to be at equilibrium, and exposure to constituents above equilibrium levels due to shutdown of the building ventilation system is assumed to be trivial in terms of exposure duration. It is assumed that flux occurs only through infiltration areas such as cracks in the building slab and that flux through the building slab itself is insignificant. Finally, all vapors originating directly below the foundation are assumed to enter the building. This is a highly conservative assumption (Johnson and Ettinger 1991).

The vapor intrusion model was proposed as a method to calculate constituent concentrations in indoor air based on specified constituent concentrations in soil gas (Johnson and Ettinger 1991). Physical parameters such as moisture content, dry-soil density, porosity, and effective air permeability affect the rate at which the vapors from a volatile constituent may migrate through the soils. The dominant mechanism of vapor migration is closely correlated with the depth to



source and soil permeabilities (Johnson and Ettinger 1991). Thus, site-specific data are fundamental to the proper application of this model. Integrated has provided DTSC with an analysis of site conditions and the projection of dominant indoor air transport mechanisms (see Appendix E). Based on this analysis, Integrated and DTSC have agreed that the dominant transport mechanism at the site is diffusion (IESI 1998b, 1998c).

For the indoor air analysis, site-specific values for these soil parameters were used when available. Conservative default values were identified based on known site characteristics for parameters that were not measured directly. Although buildings have not yet been constructed on either AOPC, the architects for the future site occupant were consulted regarding the parameters (e.g., building dimensions and foundation characteristics) for the planned building on the parcel. These building parameters were applied in each AOPC indoor air analysis.

The first step in the indoor air analysis was to estimate the concentration of constituents in soil gas as follows:

$$C_{sg} = \frac{C_s H P_s}{[P_w + K_{oc} P_s + H P_a]} \quad (5-14)$$

where

- C_{sg} = concentration in soil gas (mg/L)
- C_s = representative concentration in soil (mg/kg), from Table 5-2
- H = Henry's Law constant (unitless), from Table 5-3
- P_s = soil bulk density, 1.5 g/cm³ (Cal/EPA 1994)
- P_w = water filled porosity, 0.15 (Cal/EPA 1994)
- K_{oc} = organic carbon partition coefficient (L/kg), from Table 5-3
- P_a = air filled porosity, 0.284 (Cal/EPA 1994)



Based on the finding of diffusive-dominant transport, a soil gas (at source) to indoor air attenuation factor was calculated using Equation 23 of the Johnson and Ettinger paper (1991):

$$\alpha = \frac{\left[\frac{D_{ei} A_B}{Q_{building} L_t} \right]}{\left[1 + \frac{D_{ei} A_B}{Q_{building} L_t} \right] + \left[\frac{D_{ei} A_B L_{crack}}{D_{crack} A_{crack} L_t} \right]} \times UC1 \quad (5-15)$$

where

- α = source soil gas to indoor air attenuation coefficient (L/m³)
- D_{ei} = effective diffusivity through vadose zone (cm²/sec), from Section 5.3.1.1
- A_B = area of building foundation, 9.68 x 10⁶ cm²
- $Q_{building}$ = building volumetric exchange rate, 4.92 x 10⁶ cm³/sec
- L_t = distance from foundation to source, 61 cm
- L_{crack} = thickness of the foundation, 10 cm
- D_{crack} = effective diffusion coefficient through the crack, assumed equal to D_{ei} (cm²/sec)
- A_{crack} = crack surface area, 9.68 x 10⁴ cm²
- UC1 = unit conversion, 1000 L/m³

Indoor air concentrations calculated using this vapor intrusion model are predicted values based on site-specific and COPC-specific factors. The results of Equation 5-14 were multiplied by the results of Equation 5-15 to produce the modeled indoor air concentrations. These concentrations are summarized by AOPC in Table 5-7.



TABLE 5-7
MODELED INDOOR AIR CONCENTRATIONS (mg/m³)

COPC	AOPC 1	AOPC 2
1,1-dichloroethene	<u>3.97E-06</u>	<u>9.90E-06</u>
1,2,4-trimethylbenzene	<u>4.17E-09</u>	<u>2.07E-08</u>
1,3,5-trimethylbenzene	<u>1.21E-08</u>	<u>3.60E-08</u>
aroclor 1248	NV	NV
<u>aroclor 1254</u>	<u>NV</u>	<u>NV</u>
aroclor 1260	NV	NV
<u>arsenic</u>	<u>NV</u>	<u>NV</u>
benzo(a)anthracene	NV	NV
benzo(a)pyrene	NV	NV
benzo(b)fluoranthene	NV	NV
<u>benzo(k)fluoranthene</u>	<u>NV</u>	<u>NV</u>
bis(2-ethylhexyl)phthalate	NV	NV
chrysene	NV	NV
dibenzo(a,h)anthracene	NV	NV
fluoranthene	NV	NV
<u>indeno(1,2,3-cd)pyrene</u>	<u>NV</u>	<u>NV</u>
naphthalene	NV	NV
n-butylbenzene	<u>5.39E-09</u>	<u>1.10E-08</u>
n-propylbenzene	<u>1.53E-08</u>	<u>3.53E-08</u>
p-cymene	<u>9.32E-10</u>	<u>2.04E-09</u>
phenanthrene	NV	NV
pyrene	NV	NV
tetrachloroethylene	<u>8.28E-08</u>	<u>1.20E-07</u>
trichloroethene	<u>9.89E-08</u>	<u>3.79E-07</u>
xylene	<u>1.03E-08</u>	<u>2.17E-08</u>

NV = Not Volatile